REGIONAL INCOME INEQUALITY AND CONVERGENCE PROCESSES IN THE EU-25

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Abstract[1]

The paper stresses regional income disparities, growth and convergence in European Union (EU-25) countries during the EU pre-enlargement period (1995-2002) distinguishing also the two subgroups to the EU: the EU-15 and the EU-10 (the new member states since May 2004). We explore sigma- and beta-convergence at a highly disaggregated regional level using spatial and non-spatial techniques. Furthermore, we measure the level of income inequality and decompose it by means of the Theil index into between country and within country contributions to overall income inequality. The results show that the speed of convergence among regions in the EU is painfully slow. Furthermore, there is a distinct difference between convergence processes at the regional and at the national level. Especially in the EU-10, the catching-up at the national scale seems to be driven by some growth centers, mainly capital regions. This causes tendencies to divergence at the regional scale. Tests for spatial autocorrelation reveal that regions are strongly affected in their development by neighbouring regions.

Keywords: regional inequality, convergence, EU-25, regional interactions, spatial econometrics

JEL: R11, O11, C23, C21

[1] The authors of the paper are grateful to the Estonian Ministry of Education and Science (research project 525) and Estonian Science Foundation (grant 6475) as well the HWWA (*Hamburgisches Welt-Wirtschafts-Archiv*) for supporting our research.

1. Introduction

The paper stresses regional income disparities, growth and convergence in the European Union (EU-25) countries during the years 1995-2002 distinguishing two groups of countries within the EU-25: the EU-15 (or the so-called old member states) and the EU-10 (the accession countries during the period under observation; the new member states (NMS) since May 1, 2004). The years under observation (1995-2002) characterize the preparative period of the fifth enlargement (the so-called east—enlargement) of the EU that took place in May 2004. During this period, which in the current paper is defined as the EU pre-enlargement period, the political decisions about the candidate and the acceding countries were made.[2] The eastward enlargement of the EU brought ten new members into the union; eight of them are post-socialist countries that have successfully passed economic transition. The economic transition was a relatively rapid process, which created the institutional, legal and structural prerequisites of a functioning and potentially competitive market economy. Nowadays the new member states have a very challenging task – convergence. The task of convergence is even more challenging then the one of transition: it consists in bringing the economies of the new member states up to the average levels of the EU-15.

The EU-25, which is one of the world's most prosperous economic areas, has large economic disparities between its member states and regions. Therefore regional income disparities and convergence in the EU-25 countries is a continually important field of research, giving additional information for the development of regional policies in the European Union. The essential argument for the EU regional policy is the insight that a balanced regional development is a prerequisite for social cohesion and a long-run increase in the competitiveness of countries and regions.

We analyse income disparities of very low level of regional aggregation using mainly NUTS-3 level data.[3] In order to assess income convergence in EU-25 countries and their regions we use models of absolute and relative location and respectively both non-spatial and spatial econometrics techniques. While absolute location refers to the impact of being located at a

[2] The decisions about the candidate countries were made in 1997 (the Luxembourg group: the Czech Republic, Cyprus, Hungary, Estonia and Slovenia) and 1999 (the Helsinki group: Bulgaria, Romania, Latvia, Lithuania, Malta and Slovakia) and about the acceding countries in 2002 (the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland Slovakia and Slovenia).

[3] NUTS – Nomenclature of Statistical Territorial Units of EUROSTAT.

particular point of space, the relative location refers to the effect of neighbourhoods. The respective non-spatial econometrics techniques ordinarily focus on models of absolute location while spatial econometrics techniques concentrate on models of relative location exploring spatial dependence. These two groups of estimation techniques are complementary. We focus on the empirical testing of absolute (unconditional) and conditional convergence hypothesis implementing both non-spatial (simple OLS, including country dummies for capturing spatial heterogeneity) and spatial (Spatial Lag Models (SLM) and Spatial Error Models (SEM)) estimation techniques. Furthermore, we measure the level of income inequality and its decomposition distinguishing between and within country inequality as components of the overall income inequality by means of the Theil index.

The paper consists of eight main sections. In section 2 a brief overview of theoretical framework and some empirical results of the previous studies about regional income disparities and convergence are given. Sections 3 and 4 explore regional income disparities and their variation dynamics (sigma-convergence) during the EU pre-enlargement period. Sections 5 and 6 present the regression models used to test for beta-convergence and the main test results. The decomposition regional inequality by the mean of the Theil index is shown in section 7 and section 8 concludes.

2. Convergence, economic growth and inequality: theoretical and empirical considerations

The concept of convergence has been a central issue around which the recent decades' growth literature has evolved (see also Islam, 2003). The question is whether the income levels of poorer countries are converging to those of the richer countries or not. Economic theory does not give a unique answer to what is the direction of the income convergence processes. Both convergence and divergence (the so-called negative convergence) may occur. Based on several theories, the optimistic (mainly neoclassical growth theory) and the pessimistic (mainly endogenous growth theory) approaches of explaining convergence processes can be distinguished. The former predicts a decrease in disparities of income levels because of decreasing returns of capital and the latter continually significant and even increasing inequality because of positive returns to scale.

The endogenous growth theory considers government policy to be necessary in order to reduce inequality, while the neoclassical growth theory does not. The integration theory, the classical trade theory and the New Economic Geography (NEG) do not support clearly nor the convergence optimism neither the pessimism. NEG (Krugman 1991a) claims that location and agglomeration are playing an important role in the economic activity of a region. Among many other factors the economic situation of a region depends on interrelations to its' neighbours. Regions that are surrounded by rich neighbours, for example, have usually better chances for development than regions situated in a relatively poor neighbourhood.

The concept of convergence is related to the economic growth and inequality issues and emphasises the question summarized by the Shakespearian-like dilemma "*is income inequality harmful for economic growth*?" The relationship between economic development and income inequality is still not clear. In 1955 Simon Kuznets introduced the hypothesis of an inverted-U relationship between the economic development and inequality which has been called the Kuznets Curve ever since. According to this hypothesis income inequality ordinarily rises in the early stages of economic development and declines in the latter. Similar results are obtained by NEG-Models. Krugman's Core-Periphery Model (1991b) suggests that in the course of economic integration, decreasing transport costs to a medium level support the production in central places. However, when economic integration proceeds further to a higher level and transport costs become very low (zero) then the model predicts economic production to spread evenly across space.

Later empirical studies offer different results. In the 1990-s some consensus was in concluding that inequality is harmful for economic growth (e.g. Alesina and Rodrik, 1994). These studies were mainly carried out at country level and the conclusions were that the economies with a higher level of initial inequality are likely to experience lower growth rates in the long run. Using more sophisticated research methodologies and different datasets some authors got also results, which predicted a positive relationship between inequality and growth (e.g. Deiniger and Squire, 1996,). Forbes (2000) found a positive relationship between inequality and growth concluding that the results of the growth-inequality relationship studies remarkably depend on the datasets and estimation techniques. Differences between the results of the studies that are based on the panel data and those that are based on the cross-section data could be explained as follows 1) panel techniques look at changes within countries over time, while cross-section studies look at differences between counties with the possibility that the within-country and cross-country relationship might work through different channels; 2) panel studies look at the issue from a short-/medium-run viewpoint, while cross-section studies may investigate the relationship in the long-run period (*ibid*; see also Arbia et al. 2005). While the role of spatial interaction was generally ignored by the empirical convergence literature for a long time, a growing number of convergence studies using spatial econometric techniques emerged during the last years (e.g. Abreu et al. 2004). In the meantime there are several studies that give evidence for the importance of regional spillovers on growth- and convergence processes (e.g. Fingleton 2004, López-Bazo et al. 2004, Niebuhr 2001, Rey and Montouri 1999) confirming that regional development is affected by spatial interactions.

Thus, as we noticed from the revising of the previous studies, the empirical results of exploring income convergence, growth and inequality vary considerably depending on the chosen methods of an analysis and on the sample of the countries and periods. Neither economic theory nor previous empirical studies can give clear outlooks of regional income convergence processes in EU-25 countries and their regions; further empirical analysis is necessary for elaborating regional policy instruments.

3. Recent income disparities across regions in the EU

The analysis of regional income disparities and convergence is conducted using Eurostat GDP data as the proxies of regional income of the EU-25 countries and regions during the period 1995-2002 With the exception of Germany the regional cross-section used in our study consists of NUTS-3 level regions. The average size of the NUTS-3 regions in Germany is very small compared to the EU average. In order to reduce the cross-section's heterogeneity in the size of the regions we used the so-called German planning regions (*Raumordnungsregionen- ROR*), which comprise several NUTS-3 regions.

We use Eurostat data on GDP in purchasing powers standards (PPS), which are adjusted for national price levels. These GDP data, however, do not adjust for different price levels across regions within a country. Of course, the data which convert the regional nominal GDP to real one by taking into account of the differing price levels within countries, would be more suitable for the analysis. Unfortunately these data are not available, yet.[4]

Some characteristics of the regional units in the sample are given in table A1 in the appendix.

[4] It should be noted that Eurostat warns against using PPP adjusted GDP values to calculate growth rates over years. However, we do not analyze the dynamics of single countries or regions, but the relative development of income levels between countries and regions, which should ease the problem.

The number of regions in the EU-10 constitutes only 14% of the total number of the EU-25 regions. On average the NUTS-3 regions in the EU-10 are more than 15% larger in population and nearly six times larger in area than the regions in the EU-15. There are even more considerable differences between the individual member states. By analysing regional income disparities and by developing policy measures also this fact beside of other information should be taken into consideration.

As shown in table 1 there are extreme differences between the top end and the bottom end of the distribution of income levels in the EU-25. The income level in Inner London West, UK is with 569.8% of the average income level in the EU-25 thirty times higher than the one of the poorest region Latgale, Latvia with 18.9%. Within the old member states the income level of the poorest region (Tamega in Portugal) is almost 15 times lower than the respective income level of the richest region. In the EU-10 the respective gap indicator was 8: the poorest region is Latgale in Latvia and the richest one is Prague in the Czech Republic.

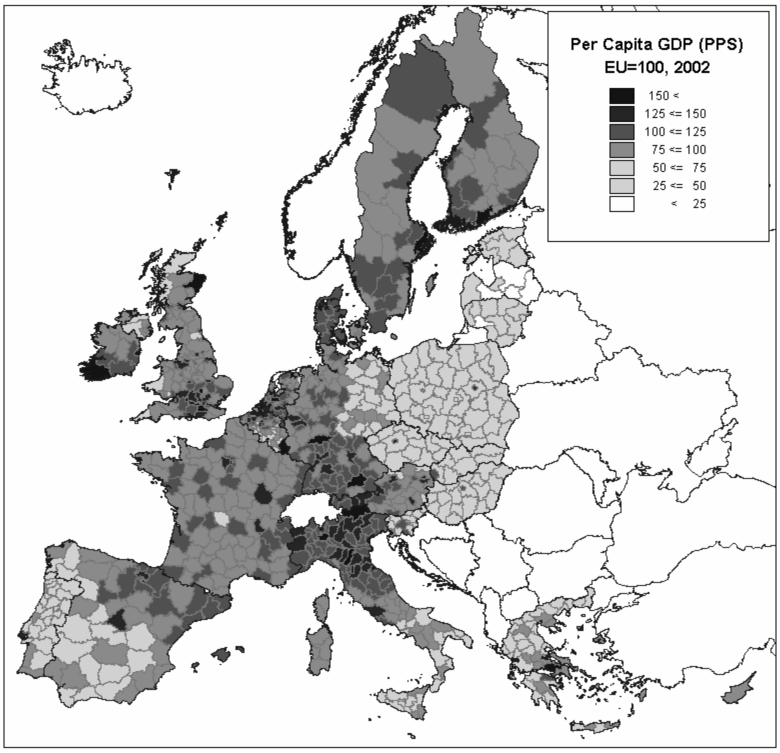
Table 1. Regional income disparities in EU-25 countries, 2002 (per cent of the EU-25 average)

	Average	**Minimum**	**Maximum**
EU-25	100.0	18.9 (Latgale, Latvia)	569.8 (Inner London West, UK)
EU-15	108.4	38.2 (Tamega, Portugal)	569.8 (Inner London West, UK)
EU-10	51.8	18.9 (Latgale, Latvia)	152.8 (Prague, Czech Republic)

Source: Eurostat, authors' computations.

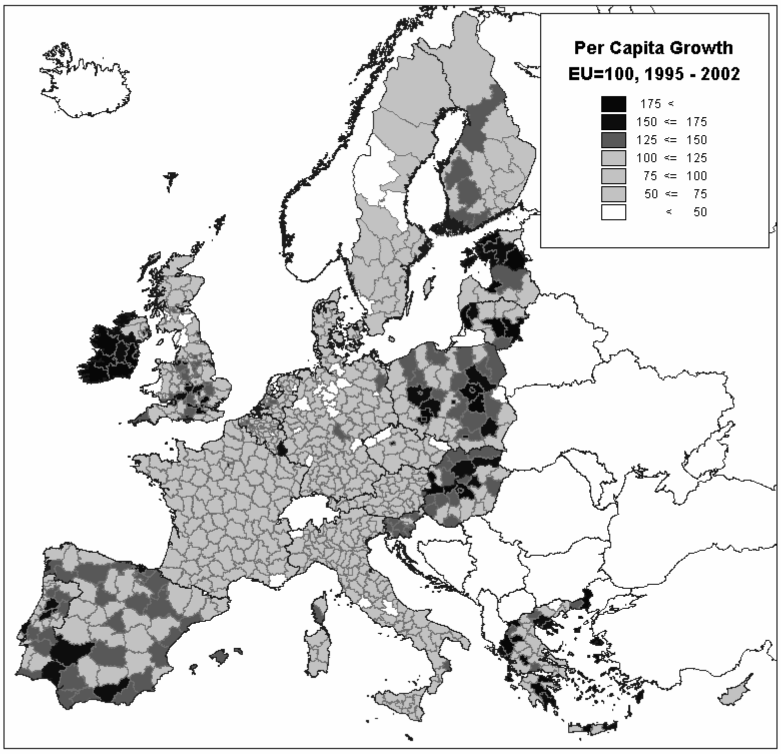
The maps in the figures 1 and 2 present regional income levels in 2002 and regional per capita growth between 1995 and 2002 relative to the respective averages of the EU-25. The few dark spots in the area of the EU-10 in figure 1 show that regions with income levels above the EU-average are the exceptions. All of these regions – Prague (152.8%), Warsaw (132.0%), Budapest (124.0%), Bratislava (119.5%) and Ljubljana (106.6%) – are exclusively capital regions. The capital regions of the three Baltic states, Tallinn, Riga and Vilnius, were with the income levels of respectively 71.3%, 70.1% and 60.1% clearly below the average of the EU-average but they are still the richest regions of their respective countries. Overall, in only a bit more than a third of the regions in the new member states income levels exceeded 50% of the EU-25 average in 2002. With the exception of regions in the Czech Republic these regions were mainly agglomerative regions (cities and their hinterland) or they share a common border to an EU-15 country.

Figure 1. Regional per capita GDP (PPS) relative to the EU-average in %, 2002



Source: Eurostat, authors' computations

Figure 2. Regional per capita growth relative to the EU-average in %, 1995 - 2002



Source: Eurostat, authors' computations

In five regions of the EU-10 the per capita incomes were below 25% of the EU-average, four of them were in Latvia and one in Lithuania. Nearly a fifth of the regions in the EU-15 experienced income levels below 75% of the EU-average. The most of these less prosperous regions of the EU-15 are situated in the peripheral parts of southern Europe, the north of the United Kingdom and eastern Germany. In 102 regions of the old member states per capita incomes exceeded 125% of the average EU-income level. Many of them belong to the so-called "blue banana" which ranges from northern Italy to the south of the United Kingdom. These regions are often believed to have good chances for development because of their centrality.

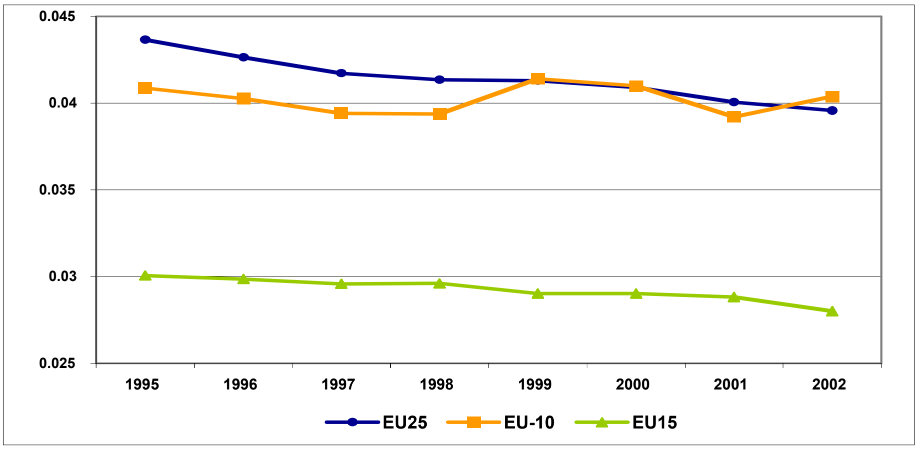
The map in figure 2 shows quite a different pattern for regional per capita growth. There was a catching-up process of most regions in the EU-10 as these regions experienced above average growth. The most dynamic were, particularly in the EU-10, the relatively rich agglomerative regions. Also some of the less prosperous regions in the southern periphery of the EU-15 experienced relatively high growth rates.

4. Dynamics of regional income variation (sigma-convergence)

Traditional empirical methodologies for testing convergence hypotheses are *beta*- and *sigma*-convergence analysis. *β*-convergence is defined as a negative relation between the initial income level and the income growth rate. If poorer economies grow faster than richer ones, there should also be a negative correlation between the initial income level and the subsequent growth rate. *Sigma*-convergence (*σ*–convergence) hypothesis examines the changes in variation of income between countries or regions. If this variation decreases over time the *sigma*-convergence hypothesis can be accepted. It should be noticed that *beta*-convergence is a necessary but not a sufficient condition for s*igma*-convergence to occur. A negative *β* from a growth-initial level regression does not necessarily imply a reduction in variation of regional income or growth rates over time.

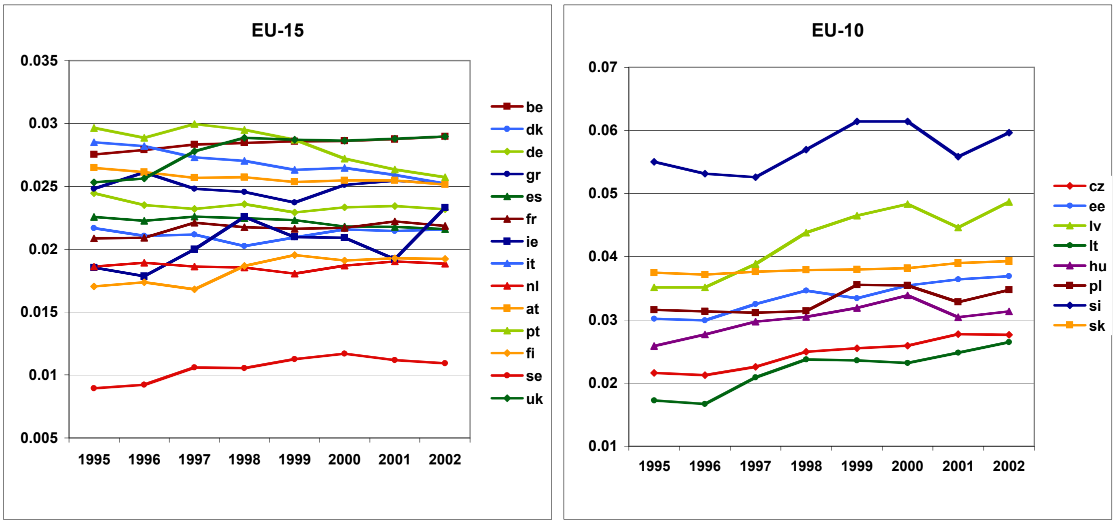
In Figure 3 the dynamics of regional income variation in the EU-25 and in the two country groups – the EU-15 and the EU-10 during the years 1995-2002 are characterized by the means of the coefficient of variation. We see that the hypothesis of *sigma*-convergence seems to be valid in the EU-25 as the whole sample of the countries under observation and also in the EU-15 but not in the case of the EU-10. Figure 4 shows the respective coefficients of variation of regional income levels within the single countries.

Figure 3. The dynamics of variation of regional income (GDP *per* capita (PPS)) in EU-25 and its' groups of countries in 1995-2002.



Source: Eurostat, authors' computations

Figure 4. The dynamics of regional income (GDP *per* capita (PPS)) variation in the countries of EU-15 and EU-10 in 1995-2002



Source: Eurostat, authors' computations

The variance in regional per capita income has been relatively stable in most of the countries in EU-15 and it has even decreased in some countries (e.g. Italy and Portugal). At the same time regional income variance has increased in all EU-10 countries. This indicates that the proof of regional sigma convergence did not occur during the EU pre-enlargement period. The fastest rise of income variation has been in Latvia, while Slovakia and the Czech Republic have experienced moderate but continuous growth.

5. Regression models

5.1 Absolute and conditional convergence

When discussing convergence processes usually the distinction between absolute and conditional convergence is made. The absolute convergence hypothesis is based on the assumption that economies (countries, regions) converge towards the same steady state equilibrium. With similar saving rates poorer countries (regions) experience faster economic growth than richer ones. This follows from the assumption of diminishing returns, which implies a higher marginal productivity of capital in a capital-poor country. The absolute convergence hypothesis argues that *per capita* incomes in different countries (regions) equalize in long run and that expresses the so-called convergence optimism.

In contrast, the concept of conditional convergence emphasizes possible spatial heterogeneity in parameters that affect growth and lead to differences in the steady state. This requires that appropriate variables are included in the right side of the growth-initial level regression in order to control for these differences. The conditional convergence hypothesis assumes that convergence occurs if some structural characteristics (like the demographic situation, government policy, human capital and employment rate, etc) have impact on income growth. Hence, conditional convergence may occur even if absolute convergence hypothesis is not valid. In the case of conditional convergence the equilibrium differs by the economy and each particular economy approaches its own unique equilibrium.

In order to test for regional convergence we use the common cross-sectional ordinary least squares (OLS) approach with the growth rate of per capita income as dependent variable and the initial income level as explanatory variable (both in natural logarithms). If dummy variables for countries are included into the equation they are supposed to pick up country-specific effects. Hence, the model with the inclusion of country dummies tests for conditional convergence, while the model without country dummies tests the hypothesis of absolute convergence. [5]

$$\ln\left(\frac{y_{i2002}}{y_{i1995}}\right) = \alpha_0 + \alpha_1 \ln(y_{i1995}) + \sum_{j=1}^{N} \alpha_{2j} d_{ji} + \varepsilon_i \qquad (1)$$

where

[5] All estimations are carried out using SpaceStat 1.90.

y_{i1995} – GDP *per capita* (PPS) in region *i* in 1995 (base year),

y_{i2002} – GDP *per capita* (PPS) in region *i* in 2002 (final year),

d_{ij} = 1 if region *i* belongs to country *j*, otherwise d_{ij} = 0,

α_0, α_1 and α_{2j} - parameters to be estimated,

ε_i – error term.

The annual rate of convergence β can be obtained using the equation $\beta = -\ln(1-\alpha_1)/T$ where *T* denotes the number of years between the initial and the final year of the observation period. Another common indicator to characterize the speed of convergence is the so-called half-life τ, which can be obtained from the expression: $\tau = \ln(2)/\beta$. The half-life shows the time that is necessary for half of the initial income inequalities to vanish. We estimate both, absolute and conditional convergence across regions in the EU. Since the convergence patterns are supposed to be different between the EU-15 and the EU-10 we estimate separate models for both country-groups as well.

5.2. Spatial interactions

The OLS estimations of the equation (1), however, assumes that all observations in the sample are independent from one another. Especially in a cross-section of regions it is likely that there is a considerable amount of spatial interaction between the regions. Ignored spatial dependence can lead to serious consequences in the estimation results. We should take into consideration that also NEG models emphasise the importance of relative location to regional development and there is empirical evidence that regions in a relatively dynamic and prosperous neighbourhood have better chance to grow than those surrounded by poor and less dynamic regions (e.g. Rey and Montouri 1999, Le Gallo et al. 2003, Egger and Pfaffermayr 2005). If it is the case, however, that the growth processes across regions are interrelated and not covered by the explanatory variables the convergence relationship may be misspecified in the equation (1).

According to Anselin (2001), spatial autocorrelation[6] can be defined as a spatial clustering of similar parameter values. If there are high or low values clustered in an area than there could

[6] We use here the terms of spatial autocorrelation and spatial dependence, though not fully correct, as synonyms.

be by a positive spatial autocorrelation. In case spatial proximity of dissimilar value there is negative spatial autocorrelation.

As measure of spatial clustering of income levels and growth in the EU we use Moran's *I*-statistic, which is a measure for global autocorrelation:

$$I_t = \frac{N\sum_{i=1}^{N}\sum_{j=1}^{N} x_{i,t}x_{j,t}w_{i,j}}{N_b\sum_{i=1}^{N} x_{i,t}^2} \quad (2),$$

where

$x_{i,t}$ - variable in question in region *i* and in year *t* (in deviations from the mean)

N – number of regions

N_b - sum of all weights (since we use row-standardised weights N_b is equal to *N)*

In order to deal with spatially dependent observations we estimate the spatial error model (SEM) and the spatial lag model (SLM), which were suggested by Anselin (1988). Both models are estimated by maximum likelihood (ML). In these models spatial dependence is taken into account by the incorporation of a spatial weight matrix *W*, which is supposed to resemble the spatial structure and intensity of the spatial effects. A common approach is to use a binary contiguity: the elements of the matrix w_{ij}=1 if the region *i* and region *j* shares a common border or is within a certain distance to each other and w_{ij}=0 otherwise.

The weight matrix we use is based on the squared inverse of the great circle distance between the geographic centres of the regions. Furthermore, we implement a critical distance cut-off, above which spatial interaction is assumed to be zero. The functional form of the squared inverse of the distances can be interpreted as reflecting a gravity function (see also Le Gallo et al. 2003). The distance matrix is row-standardized so that it is relative and not absolute distance that matters.

It has to be noted that the estimation results are affected by the choice of the weight matrix. Furthermore, the results can be influenced by the choice for the level of regional aggregation. As a consequence of the small regional units chosen for this analysis the detection of spatial autocorrelation could be an artifact of separating homogenous zones with respect to the considered variable. Conversely in a cross-section consisting of larger regional units there is a higher probability of hidden heterogeneity within the units. Thus, both, the choice for the spatial weight and the choice level of regional aggregation are somewhat arbitrary but the possible consequences have to be kept in mind (see also Ertur and Le Gallo 2003).

We estimate the following spatial error model (SEM) including country dummies:

$$\ln(\frac{y_{i2002}}{y_{i1995}}) = \alpha_0 + \alpha_1 \ln(y_{i1995}) + \sum_{j=1}^{N} \alpha_{2j} d_{ji} + \varepsilon_i \text{, with } \varepsilon_i = \lambda[W \cdot \varepsilon]_i + u_i \qquad (3),$$

where

λ is spatial autocorrelation coefficient,

$[W \cdot \varepsilon]_i$ is the *i*-th element from the vector of the weighted errors of other regions,

$d_{ij} = 1$ if region *i* belongs to country *j*, otherwise $d_{ij} = 0$,

α_0, α_1 and α_{2j} - parameters to be estimated,

ε_i and u_i are normally independently distributed error terms.

In the spatial error model spatial dependence is restricted to the error term, hence on average per capita income growth is explained adequately by the convergence hypothesis. The SLM, therefore, is an appropriate model specification for the nuisance form of spatial dependence (see also Niebuhr (2001).

The spatial lag model (SLM) is suitable if the ignored spatial effects are of the substantial form, where regional growth is directly affected by the growth rates of the surrounding regions. The growth effects from the neighbouring regions are incorporated through the inclusion of a spatial lag of the dependent variable on the right-hand side of the equation:

$$\ln(\frac{y_{i2002}}{y_{i1995}}) = \alpha_0 + \rho \left[W \cdot \ln(\frac{y_{2002}}{y_{1995}}) \right]_i + \alpha_1 \ln(y_{i1995}) + \sum_{j=1}^{N} \alpha_{2j} d_{ji} + \varepsilon_i \qquad (4)$$

where

ρ is the spatial autocorrelation coefficient,

W the weight matrix and $\left[W \cdot \ln(\frac{y_{2002}}{y_{1995}}) \right]_i$ is the *i*-th element of the vector of weighted growth rates of other regions; other denotations see by the equation (3).

6. Estimation Results

6. 1. The non-spatial estimations

Before we turn to the spatial regression models, we ignore spatial dependence and estimate the OLS model of equation (1) testing absolute and conditional convergence and analysing the speed of convergence in the regions of the EU-25 during the years 1995-2002. Of course, we should be rather careful by making comprehensive conclusions from all estimations based on data of this very short time period.

We analyse absolute and conditional convergence across the EU-25, the EU-15 and the EU-10 regions during the EU pre-enlargement period. The estimation results of the OLS regressions are presented in the table A2 in the appendix. The estimated average absolute convergence rate during the period 1995-2002 was 1.4% in the EU-25 and 1.5% in the EU-15. Giving that rate of convergence it would take about 49 years for half of the initial regional income levels' differences to vanish in EU-25 and 47 years in EU-15. The parameter β as an absolute convergence speed indicator is not statistically significant in the case of the EU-15 regions and therefore the absolute convergence hypothesis is not proven.

If we include country dummies into equation (1) and thus test the conditional convergence hypothesis the rate of conditional convergence is much lower than of unconditional convergence, only 0.2% in the EU-15 and in the EU-25. In the case of EU-10 regions the parameter β is negative. Thus, the estimators imply that a strong divergence process took place among the regions in the EU-10 with the regional disparities increasing annually by 2.2% between 1995 and 2002. The catching-up of the poor EU-10 at the national level seems to be driven mainly by a few high growth regions.

6.2 Estimations of the spatial econometric models

According to Moran's *I*-test for spatial autocorrelation there is strong evidence for spatial dependence among the regions in the EU. Table 2 shows the Moran coefficient *I* using the weight matrix as specified above.

Different critical distance cut-off points were implemented in order to check for the sensitivity to changes in the spatial weight. Growth rates and income levels in 1995 and 2002 are more spatially clustered than they could be by pure random. In all cases Moran's *I* is highly significant. The coefficient is highest with the lowest distance cut-off of a hundred kilometres and is decreasing with increasing distance cut-offs. However, the significance is lower with short distance cut-offs and highest with the cut-off at around 500 km. With larger distance cut-offs both, the coefficient *I* and it's significance, are decreasing. This indicates that the intensity of spatial dependence declines with larger distances. In this paper we present the estimation results using 500 km as critical distance cut-off. The use of other distance cut-offs did not affect the results significantly.

Table 2. Moran's *I*-test for spatial autocorrelation (randomization assumption)

Critical cut-off distance of the spatial weight in (km)	Moran coefficient I (Standardised z-value)		
	$\ln\left(\frac{y_{i2002}}{y_{i1995}}\right)$	$\ln(y_{i1995})$	$\ln(y_{i2002})$
100	0.46 (18.24)**	0.76 (30.15)**	0.67 (26.53)**
200	0.44 (25.09)**	0.75 (42.60)**	0.66 (37.55)**
300	0.41 (26.81)**	0.72 (47.57)**	0.64 (41.90)**
400	0.38 (27.09)**	0.70 (49.98)**	0.62 (43.97)**
500	0.36 (27.29)**	0.68 (51.11)**	0.60 (44.96)**
600	0.35 (27.13)**	0.66 (51.08)**	0.58 (44.93)**
700	0.34 (27.09)**	0.64 (50.93)**	0.56 (44.80)**
800	0.33 (26.91)**	0.62 (50.52)**	0.55 (44.47)**
900	0.32 (26.69)**	0.61 (50.05)**	0.53 (44.07)**
1000	0.32 (26.49)**	0.59 (49.56)**	0.52 (43.66)**
2000	0.29 (25.39)**	0.53 (46.89)**	0.47 (41.41)**

** significant at the 0.01 level.

The Moran's *I* coefficient detects spatial autocorrelation but cannot tell whether it is of the nuisance or of the substantive form. While the former would lead to invalidity of the significance tests, the latter would lead to biased estimation results. According to the decision rule by Anselin and Florax (1995), the Lagrange multiplier tests for spatial error and spatial lag dependence point to the existence of the substantive form. The test for spatial lag dependence is significant in all six cases. The robust versions of the LM tests, which are robust to the presence of the respective other form of spatial dependence, give no clear indication. The Koenker-Bassett and the Breusch-Pagan tests, respectively, detect a problem of heteroscedasticity in the conditional convergence estimations for the EU-25 and the EU-10. Heteroscedasticity can be a cause of spatial autocorrelation and vice versa. Furthermore, the Jarque-Bera test rejects normality of the error terms in all OLS estimations. According to

Anselin (1992) tests for heteroscedasticity and spatial dependence should be interpreted with caution, since they are based on the normality assumption.

We estimate both models, the SEM and the SLM. The estimation results are presented in tables A3 and A4 in the appendix. The modelling results in the case of the SLM and the SEM, however, are very similar. The coefficients of the spatially lagged dependent variable (ρ) and of the lagged error (λ) are all statistically highly significant indicating that regions are strongly affected in their development by neighbouring regions. In the model specifications without control for country specific effects, there are remarkable differences in the estimated speed of convergence in the EU-25 and the EU-15, when spatial effects are considered. The annual rates of convergence are close to zero in both spatial model specifications. While there was no significant convergence in the EU-10 when no country dummies are included, neither in the OLS-estimation nor in the SLM, the spatial error model indicates significant divergence with a rate of 1.1% per year. What remains the same in all model specifications is the fact, that a significant divergence process took place between 1995 and 2002 in the EU-10 when national effects were taken into account ($\beta = -2.0$) [7]. The spatial Breusch-Pagan test and the LM tests show that there is still some remaining heteroscedasticity and/or spatial dependence in the estimations.

The divergence process in the EU-10 when country specific effects are taken into account indicates that the catching-up of the poor EU-10 at the national level seems to be driven mainly by the few high growth regions. These results are also in accordance with the findings of Niebuhr and Schlitte (2004), which are based on using non-spatial estimation techniques and NUTS-2 level data of GDP *per capita* (Euro) during the period 1995-2000. Also the findings of several other studies indicate that the high growth regions coincide essentially with highly competitive agglomerations and thus, the regions that are already marked by relatively high income levels (see Tondl and Vuksic, 2003). The decline of income disparities between the countries in the EU is often accompanied by the increasing regional disparities within the new member states stressing the necessity to improve conditions for economic growth at the national as well regional level.

[7] It should be mentioned that the direct comparison of the β-coefficients of the SLM and the OLS-model is not quite correct because the estimated speed of convergence in the SLM comprises also indirect and induced effects. See more details in Abreu et al. (2004) or Egger and Pfaffermayr (2005).

7. Regional income inequality and its decomposition

Inequality is often measured by means of an index able to reflect the degree of variation of the income between different agents (individuals, regions, etc). In this paper we use the Theil index in order to measure regional income inequality at the regional level of the EU-25.

The overall regional income inequality can be measured by the following Theil index:

$$T_{overall} = \sum_i \left(\frac{N_i}{N}\right) T_i + \sum_i \left(\frac{N_i}{N}\right) \ln\left(\frac{N_i / N}{Y_i / Y}\right) = T_{within} + T_{between} \qquad (5),$$

where

Y_{ij} – the income of the region j in the country i,

Y – the total income of all regions ($= \sum_i \sum_j Y_{ij}$),

N_{ij} – the population of the the region j in the country i,

N - the total income of all regions ($= \sum_i \sum_j N_{ij}$),

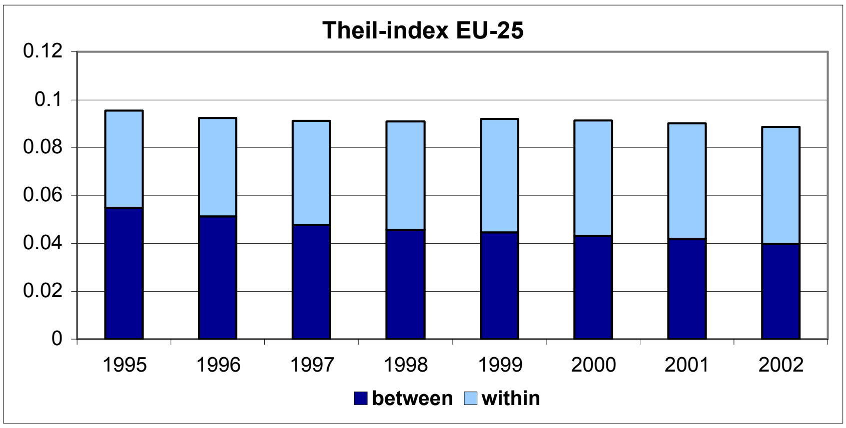
$$T_i = \sum_j \left(\frac{N_{ij}}{N_i}\right) \ln\left(\frac{N_i / N_i}{Y_{ij} / Y_i}\right) \qquad (6).$$

Equation (6) is the ordinary Theil inequality decomposition in which the overall income inequality is the sum of the between-country and the within–country components. The within-country component characterizes the income inequality between the regions in each country of the EU-25, while the between-country component measures the inequality between these countries.

In order to analyze the dynamics of regional income inequality in the EU-25 and its groups of countries (EU-15, EU-10) during the years 1995-2002 we decomposed the overall measure of inequality into between-country and within-country components. Figure 5 illustrates the evolution of regional income disparities in EU-25. The overall income inequality has a bit decreased in EU-25 during the period under observation due to the decline in between country inequality. The patterns of the overall inequality decomposition differ between EU-15 and

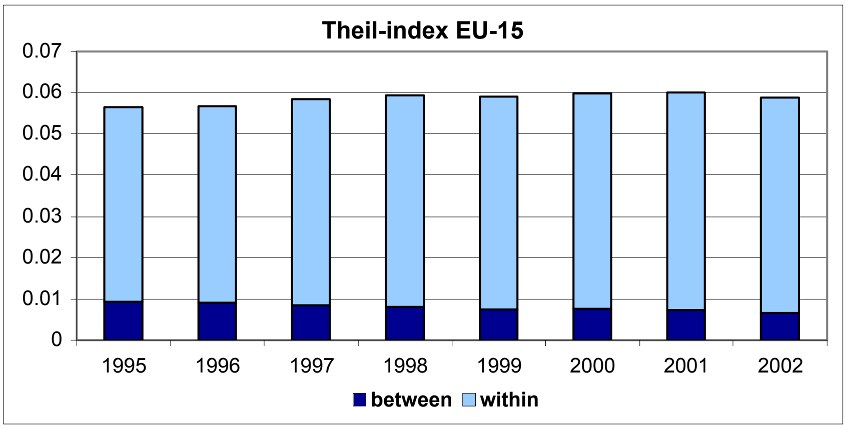
EU-10 (see figures 6 and 7).

Figure 5. Regional income inequality decomposition in EU-25 during the years 1995-2002



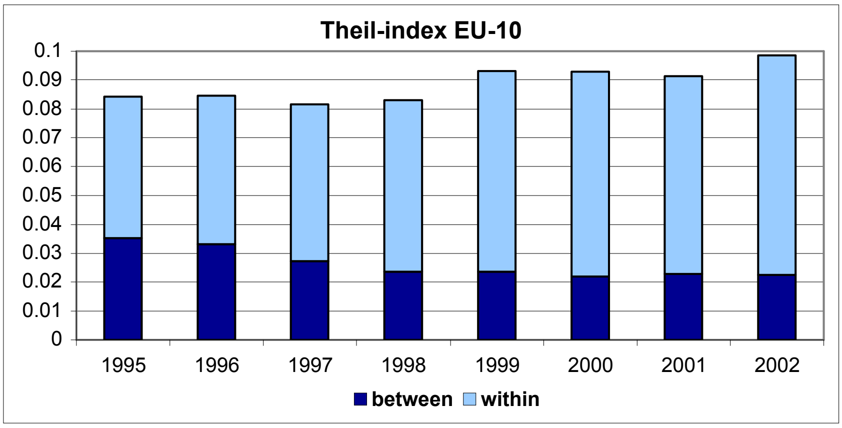
Source: Eurostat, authors' computations

Figure 6. Regional income inequality decomposition in EU-15 during the years 1995-2002



Source: Eurostat, authors' computations

Figure 7. Regional income inequality decomposition in the EU-10 during the years 1995-2002



Source: Eurostat, authors' computations

The level of overall income inequality in the EU-15 slightly increased during the period under observation. This was mainly driven by an increase of the within-country component. The within-country component is establishing around 87% of the overall income inequality of the EU-15 countries and around 78% of the EU-10. The share of the between country inequality is declining in both groups of countries but this decrease is slower in EU-15 than in EU-10. The share of the within country inequality is increasing in EU-10.

Thus, during the transition and European integration processes, which are characterized by comparatively quick economic growth in the majority of accession countries, the income differences between the countries declined but regional income disparities within the countries increased remarkably. This confirms the findings of the analyses above that the catching-up process of the new member states at the national level was mainly driven by a few high-growth regions.

8. Conclusions

The results of the EU-25 regional income analyses during the EU pre-enlargement period (1995-2002) show significant regional disparities in both the old and new member states (the accession countries during the pre-enlargement period). The differences between the highest and lowest income levels of regions in the EU-25 in 2002 were more than 30-fold. The relatively wealthy regions, especially in the EU-10, are mostly capital regions. These were also mainly the regions that experienced the fasted growth during the period under observation.

Not only the differences were large, also the speed of regional income convergence was slow as shown by *sigma*- and *beta*-convergence analysis. When spatial effects are taken into account in the estimation of beta-convergence there is no considerable convergence found in none of the groups of countries (EU-25, EU-15 and EU-10). The control for country specific effects reveals even a significant process of divergence across regions in the new member states (the EU-10).

The decomposition of the overall regional inequality measured by Theil index into between-country and within-country components in EU-25 and its groups of countries (EU-15 and EU-10) show a small decline of overall income inequality caused by the decline of between-country inequality, particularly in EU-10. The share of the within-country component in overall regional inequality is increasing. The patterns of the overall inequality decomposition somewhat differ between the EU-15 and theEU-10. The decrease of the between country inequality is quicker in EU-10 than in EU-15. The EU-10 experienced comparatively quick economic growth but the catching-up process at the national level was mainly driven by a few high growth regions and therefore regional income inequality within the EU-10 increased significantly.

Altogether, the results of our analysis assert continuing importance of the European Union regional policy for reducing regional income disparities in both, old and new member states. The results also allow us to suggest that in the conditions of quick economic growth and increasing regional inequality within the countries governmental intervention might be necessary. Even if in later phases of economic integration the gravitational forces may prevail and foster convergence, the increasing inequality may produce dissatisfaction of people, weaken cohesion of society and thus may in the long run lower the country's competitiveness and economic growth. Therefore it is important to establish opportunities for poorer regions to stimulate their economic growth by giving them chances to effectively take over innovations created in richer regions. Systematic investments into local human capital and stimulating labour force mobility are necessary to accomplish that.

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Appendix

Table A1. The regional cross-section and characteristics of the regions

	Number of regions	Classification	Average population per region in 1000	Average Area per region in square kilometres	Average population density per region (inhabitants per square kilometres)
EU-25	***861***	***NUTS-3/ROR***	***529.3***	***4521.1***	***117.1***
EU-15	***739***	***NUTS-3/ROR***	***516.2***	***2707.1***	***190.7***
Belgium	43	NUTS-3	240.2	709.7	338.5
Denmark	15	NUTS-3	358.4	2873.0	124.7
Germany	97	ROR	850.3	3680.6	231.0
Finland	20	NUTS-3	260.1	15226.5	17.1
France	96	NUTS-3	639.9	5666.3	112.9
Greece	51	NUTS-3	215.5	2580.9	83.5
Ireland	8	NUTS-3	490.8	8784.1	55.9
Italy	103	NUTS-3	554.9	2925.6	189.7
Luxembourg	1	NUTS-3	446.0	2586.4	172.4
Netherlands	40	NUTS-3	403.7	846.8	476.7
Austria	35	NUTS-3	231.0	2396.0	96.4
Portugal	28	NUTS-3	370.3	3282.4	112.8
Sweden	21	NUTS-3	425.0	19568.3	21.7
Spain	48	NUTS-3	860.7	10516.5	81.8
United Kingdom	133	NUTS-3	446.0	1833.2	243.3
EU-10	***122***	***NUTS-3***	***608.5***	***15509.6***	***39.2***
Estonia	5	NUTS-3	272.2	9045.5	30.1
Latvia	6	NUTS-3	389.8	10764.8	36.2
Lithuania	10	NUTS-3	346.9	6530.0	53.1
Malta	1	NUTS-2	396.0	316.0	1253.2
Poland	45	NUTS-3	849.6	6948.6	122.3
Slovakia	8	NUTS-3	672.4	6129.4	109.7
Slovenia	12	NUTS-3	166.3	1689.4	98.4
Czech Republic	14	NUTS-3	728.6	5632.9	129.4
Hungary	20	NUTS-3	508.0	4651.5	109.2
Cyprus	1	NUTS-3	710.0	9250.0	76.8

Source: Eurostat, authors' computations

NUTS – Nomenclature of Statistical Territorial Units of EUROSTAT; ROR - Raumordnungsregionen

Table A2. OLS-estimations

	EU-25	EU-15	EU-10	EU-25	EU-15	EU-10
Country Dummies	*no*			*yes*		
Number of Regions	*861*	*739*	*122*	*861*	*739*	*122*
Intercept	1.224** (13.92)	1.25** (8.35)	0.582 (1.93)	0.239* (2.02)	0.67** (4.42)	-1.136** (-3.12)
α_1	-0.094** (-10.21)	-0.097** (-7.93)	-0.020 (-0.57)	0.011 (0.88)	-0.016** (-1.31)	0.163** (4.34)
$\mathbf{R}^2_{adj.}$	0.13	0.08	0.003	0.39	0.38	0.31
AIC	-1488.1	-1344.4	-162.24	-1771.5	-1607.2	-200.3
β	1.4**	1.5**	0.3	0.2	0.2**	-2.2**
Half-life	49	47	240	439	301	-
Normality Jarque-Bera	260.34**	225.96**	11.62**	202.24**	183.05**	7.82*
Heteroscedasticity Koenker-Bassett Breusch-Pagan	0.38	0.29	5.68*	148.44**	134.21**	19.00*
Spatial Dependence						
Moran's I	17.66**	18.49**	4.58**	7.87**	6.72**	2.99**
LM $_{Error}$	298.82**	326.32**	16.41**	34.04**	25.81**	2.35
Robust LM $_{Error}$	6.43*	0.06	3.55	2.30	3.75	1.24
LM $_{Lag}$	326.13**	369.53**	13.71**	32.27**	22.29**	4.47*
Robust LM $_{Lag}$	33.74**	43.28**	0.86	0.53	0.23	3.35

**significant at the 0.01 level *significant at the 0.05 level.

Table A3. Spatial lag model

	EU-25	EU-15	*EU-10*	*EU-25*	*EU-15*	*EU-10*
Country Dummies		*no*			*yes*	
Number of Regions	*861*	*739*	*122*	*861*	*739*	*122*
Intercept	0.369** (16.12)	0.378** (3.52)	-0.03 (-0.01)	0.067 (0.57)	0.547** (3.64)	-1.14** (-3.35)
α_1	-0.029** (-3.83)	-0.031** (-2.90)	0.025 (0.877)	0.016 (1.32)	-0.012 (-1.01)	0.164** (4.65)
ρ	0.715** (16.12)	0.746** (16.86)	0.455** (3.91)	0.352** (5.19)	0.338** (4.49)	0.299* (1.96)
AIC	-1681.2	-1539.3	-172.9	-1795.3	-1623.7	-202.1
β	0.4**	0.4**	-0.4	-0.2	0.2	-2.2**
Half-Life	165	154	-	-	402	-
Heteroscedasticity Spatial Breusch-Pagan	17.89**	2.33	2.93	352.57**	298.68**	27.29**
Spatial Error Dependence Lagrange Multiplier	24.43**	11.07**	0.99	0.37	1.02	3.14

**significant at the 0.01 level. *significant at the 0.05 level.

Table A4. Spatial error model

	EU-25	*EU-15*	*EU-10*	*EU-25*	*EU-15*	*EU-10*
Country Dummies		*no*			*yes*	
Number of Regions	*861*	*739*	*122*	*861*	*739*	*122*
Intercept	0.440** (3.71)	0.484** (3.34)	-0.334 (-1.15)	0.181 (1.47)	0.675** (4.25)	-1.013** (-3.05)
α_1	-0.013 (-1.04)	-0.018 (1.21)	0.080* (2.44)	0.016 (1.24)	-0.014 (-1.04)	0.150** (4.37)
λ	0.781** (19.87)	0.774** (18.28)	0.701** (7.08)	0.390** (5.56)	0.370** (4.84)	0.291 (1.79)
AIC	-1678.0	-1534.7	-180.8	-1799.0	-1628.2	-202.8
β	0.2	0.3	-1.1*	-0.2	0.2	-2.0**
Half-Life	371	267	-	-	344	-
Heteroscedasticity Spatial Breusch-Pagan	22.63**	5.39*	0.06	356.33**	299.27**	26.08**
Spatial Lag Dependency Lagrange Multiplier	22.71**	10.06**	0.86	2.82	0.74	0.07

**significant at the 0.01 level. *significant at the 0.05 level.